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WADD-TR-60-142

960300

OPERATIONAL EVALUATION OF PRODUCTION AN/ARC-58 RADIO SET

203 100

Collins Radio Company

JANUARY 1960

Contract No. AF 30(635)-4504

WRIGHT AIR DEVELOPMENT DIVISION

WADD-TR-60-142

OPERATIONAL EVALUATION OF PRODUCTION AN/ARC-58 RADIO SET

Collins Radio Company

Report No. CER-1113

JANUARY 1960

Communication and Navigation Laboratory
Contract No. AF 30(635)-4504
Item 56
Project No. 4562(RADC)
Task No. 43073

WRIGHT AIR DEVELOPMENT DIVISION
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

200 – October 1960 – 4-217

ABSTRACT

This report describes the results of the operational evaluation of production AN/ARC-58 Single Sideband Communications Radio Sets conducted in accordance with item 55 of Contract AF 30(635)-4504.

This program was conducted utilizing production AN/ARC-58 Radio Sets in four (4) KC-135 aircraft operating at Castle Air Force Base and six (6) B-52 aircraft operating at Travis Air Force Base.

The AN/ARC-58 during the test program averaged approximately 175 hours per equipment for a total flight time accumulation of 1750 hours. The production AN/ARC-58 demonstrated a mission MTBF of 292 hours. The production AN/ARC-58 in the KC-135 aircraft demonstrated an MTBF of 423 hours; the production AN/ARC-58 in the B-52 aircraft demonstrated an MTBF of 226 hours.

The results of this evaluation indicate about a 3.4 to 1 improvement when comparing performance and reliability of the production AN/ARC-58 system to that of the preproduction AN/ARC-58 system. Data on preproduction equipment was obtained from a previous study.

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SECTION I

INTRODUCTION

The purpose of this report is to describe the results of the operational evaluation of production AN/ARC-58 Radio Sets conducted in accordance with item 55 of Contract AF 30(635)-4504. This report is submitted in accordance with item 56.

The AN/ARC-58 is a high-frequency communications radio set designed to provide reliable, long-distance, two-way communication for ground-to-air, air-to-ground, and point-to-point service in the h-f frequency band. The AN/ARC-58 was developed by Collins Radio Company under the direction of the Rome Air Development Center with technical assistance provided by the Wright Air Development Center.

The purpose of the operational evaluation program was to determine the reliability of production AN/ARC-58 and to compare this value with the reliability of preproduction systems determined by an Employment and Suitability Testing Program previously conducted on preproduction AN/ARC-58. The E&ST program was conducted and the report prepared in accordance with items 53 and 54 of the subject contract.

SECTION II

EVALUATION PROCEDURES

2.1 SYSTEM DESCRIPTION

Radio Set AN/ARC-58 is designed to provide reliable communication for ground-to-air, air-to-ground, and point-to-point service in the high frequency band. The AN/ARC-58 employs single-sideband techniques and features full coverage of the h-f spectrum from 2.0 MC to 29.999 MC in 1-KC increments, frequency stability of 1 part in 10^6 per month, simplified frequency selection using direct reading digital dials, compatibility with existing AM equipment, and fully automatic tuning.

2.2 AN/ARC-58 INSTALLATIONS

The evaluation was conducted at Castle Air Force Base and Travis Air Force Base utilizing four KC-135 aircraft and six B-52 aircraft. The AN/ARC-58 Radio Sets in the B-52 aircraft at Travis AFB were installed by the air-frame manufacturer. The production AN/ARC-58's were installed in the selected KC-135 aircraft at Castle AFB by Air Force Personnel.

2.2.1 AN/ARC-58 Installation in KC-135 Aircraft

The components of the AN/ARC-58 installation in the KC-135 aircraft are listed in table 2-1.

2.2.2 AN/ARC-58 Installation in B-52 Aircraft

The components of the AN/ARC-58 installation in the B-52 aircraft are listed in table 2-2.

2.2.3 Antenna Types

The long-wire antenna was employed on both KC-135 and B-52 aircraft during the evaluation of the production AN/ARC-58. The KC-135 aircraft 57-2601 was fitted with a probe antenna during a portion of the evaluation program for a study conducted by the Air Force.

TABLE 2-1. COMPONENTS OF AN/ARC-58 INSTALLATION IN KC-135

QTY	NOMENCLATURE	DESCRIPTION
2 ea	C-1939/ARC-58	Radio Set Control
1 ea	R-761/ARC-58	Radio Receiver-Exciter
1 ea	T-605/ARC-58	Radio Transmitter
1 ea	CU-523/ARC-58	Antenna Coupler
1 ea	C-1940/ARC-58	Antenna Coupler Control
1 ea	HD-277/U	Vaneaxial Fan
1 ea	CY-2059/ARC-58	Transmitter Case
1 ea	MT-1698/U	Mounting
1 ea	MT-1699/U	Mounting
1 ea	MT-1700/U	Mounting
1 ea	MT-1728/U	Mounting
NOTE: The above list does not include miscellaneous hardware relating to the antenna system, junction boxes, connectors, etc.		

2.2.4 Test Equipment

The test equipment used for AN/ARC-58 bench maintenance at Castle and Travis Air Force Bases is listed in appendices III and IV respectively.

2.3 DATA COLLECTION

The evaluation program was scheduled to start 15 June 1959. Collins field engineers were assigned to Castle Air Force Base and Travis Air Force Base to monitor the program and assemble the necessary data for forwarding to the Collins Reliability Department. The performance data were forwarded for evaluation on a weekly basis.

TABLE 2-2. COMPONENTS OF AN/ARC-58 INSTALLATION IN B-52

QTY	NOMENCLATURE	DESCRIPTION
1 ea	C-1939/ARC-58	Radio Set Control
1 ea	R-761/ARC-58	Radio Receiver-Exciter
1 ea	T-605/ARC-58	Radio Transmitter
1 ea	CU-523/ARC-58	Antenna Coupler
1 ea	C-1940/ARC-58	Antenna Coupler Control
1 ea	HD-266/ARC-58	Electronic Equipment Cooler
1 ea	MT-1699/U	Mounting
1 ea	MT-1700/U	Mounting
1 ea	MT-1728/U	Mounting
1 ea	SA-377/ASQ	Pressure Switch
1 ea	HD-186/ASQ	Desiccant Dehydrator
1 ea		Pressure Pump

NOTE: The above list does not include components of the ground blower system nor miscellaneous hardware relating to the antenna system, junction boxes, connectors, etc.

The Collins field engineer who was previously assigned to Castle Air Force Base for the E&ST preproduction AN/ARC-58 study was again assigned to Castle Air Force Base for this study. The Collins field engineer at Travis Air Force Base was on permanent assignment at that site to provide technical assistance in equipment maintenance and on-the-job technical training of Air Force personnel.

The Collins field engineers were briefed on the requirements of the evaluation program and were supplied with preprinted forms and a data collection procedure booklet. Prior

to the start of the program the Collins field engineers and Air Force personnel of the Operational Engineering Sections at Castle Air Force Base and Travis Air Force Base formulated the procedures established to ensure that all pertinent data was obtained for evaluation. Close coordination between Collins and Air Force personnel was maintained throughout the evaluation program.

2.3.1 Data Report Forms

The data reporting forms used in the evaluation were:

(1) Aircraft Radio Log - This form is a standard Air Force form No. 35 used to record all pertinent information regarding communication traffic.

(2) Weekly Status Report - This form provides a summary of AN/ARC-58 performance in flight and on the ground during the reporting week.

(3) Failure-Malfunction Report - This form is used to record all AN/ARC-58 failure or malfunctions either during flight or on the ground.

The "Data Collection Procedures" booklet, which included illustrations of the reporting forms, is illustrated in appendix I.

2.4 DATA EVALUATION

The production AN/ARC-58 data evaluation became a part of the formal AN/ARC-58 Reliability Program which has been in effect since April 1957. The Collins AN/ARC-58 Reliability Program is described in appendix II. The AN/ARC-58 performance data were processed and evaluated by the Reliability Engineering Group of the Reliability Department.

SECTION III

RESULTS OF THE EVALUATION

3.1 AIRCRAFT MISSIONS BY MONTH AND PERFORMANCE OF AN/ARC-58

The KC-135 and B-52 aircraft missions flown during this study and the performance of the AN/ARC-58 as a communication medium during each mission are illustrated in figure 3-1.

All missions are coded on the chart as being satisfactory, satisfactory with write-up, or unsatisfactory. Also coded on the chart is the reason for the classification of satisfactory with write-up or unsatisfactory mission.

There were 22 missions flown during which the AN/ARC-58 was turned on but was used on receive only because of Air Force scheduling. These flights were also classified and are included in figure 3-1. The AN/ARC-58 was not used during two B-52 missions because the long-wire antenna failures, experienced during the flights of aircraft 57-6510 on 15 July and aircraft 57-6514 on 23 July, had not been repaired.

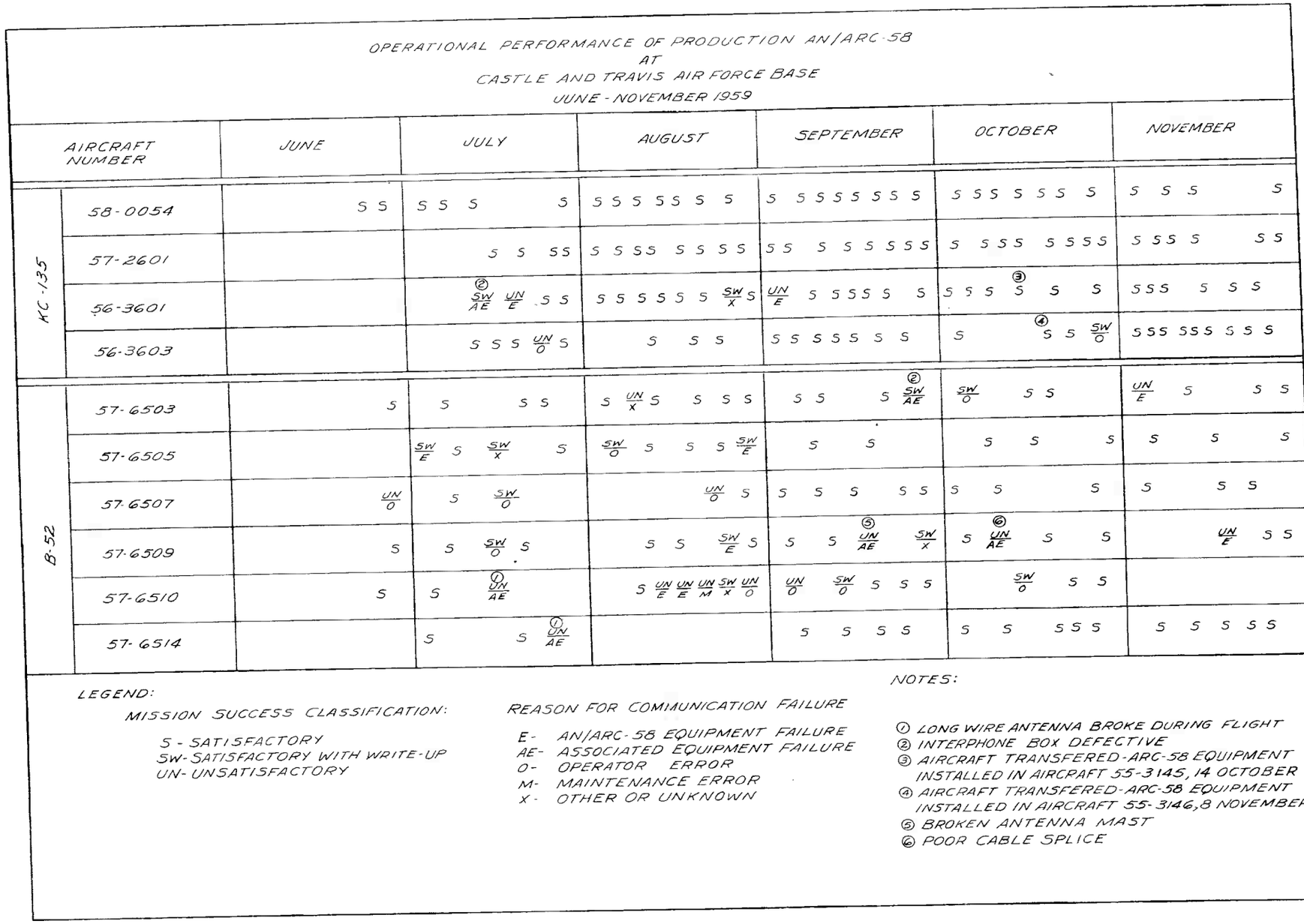
3.1.1 Mission Success Classifications

Mission success was determined by the performance of the AN/ARC-58 equipment during each mission. The mission success classifications and codes used are as follows:

S - Satisfactory - AN/ARC-58 communication was maintained throughout the mission.

SW - Satisfactory with Write Up - Satisfactory communication was possible; however, difficulty was experienced due to fault classifications itemized below.

UN - Unsatisfactory - Unsatisfactory communication was experienced during the mission. Contacts were attempted with no success. Reasons for this classification are also itemized under fault classification below.



OPERATIONAL PERFORMANCE OF PRODUCTION AN/ARC-58
AT
CASTLE AND TRAVIS AIR FORCE BASE
JUNE - NOVEMBER 1959

	AIRCRAFT NUMBER	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER
KC-135	58-0054	S S	S S S S	S S S S S S S	S S S S S S S S	S S S S S S S	S S S S
	57-2601		S S SS	S S SS S S S S	SS S S S S S S	S S S S S S S S	S S S S S S
	56-3601		(2) SW/AE UN/E S S	S S S S S S SW/X S	UN/E S S S S S S	S S S (3) S S S	S S S S S S S
	56-3603		S S S UN/O S	S S S	S S S S S S S	S (4) S S SW/O	S S S S S S S S S
B-52	57-6503	S	S S S	S UN/X S S S S	S S S (2) SW/AE	SW/O S S	UN/E S S S
	57-6505		SW/E S SW/X S	SW/O S S S SW/E	S S	S S S	S S S
	57-6507	UN/O	S SW/O	UN/O S	S S S S S	S S S	S S S
	57-6509	S	S SW/O S	S S SW/E S	S S (5) UN/AE SW/X	S (6) UN/AE S S	UN/E S S
	57-6510	S	S (1) UN/AE	S UN/E UN/E UN/M SW/X UN/O	UN/O SW/O S S S	SW/O S S	
	57-6514		S S (1) UN/AE		S S S S	S S S S S	S S S S S

LEGEND:

MISSION SUCCESS CLASSIFICATION:

S - SATISFACTORY
SW - SATISFACTORY WITH WRITE-UP
UN - UNSATISFACTORY

REASON FOR COMMUNICATION FAILURE

E - AN/ARC-58 EQUIPMENT FAILURE
AE - ASSOCIATED EQUIPMENT FAILURE
O - OPERATOR ERROR
M - MAINTENANCE ERROR
X - OTHER OR UNKNOWN

NOTES:

(1) LONG WIRE ANTENNA BROKE DURING FLIGHT
(2) INTERPHONE BOX DEFECTIVE
(3) AIRCRAFT TRANSFERED-ARC-58 EQUIPMENT INSTALLED IN AIRCRAFT 55-3145, 14 OCTOBER
(4) AIRCRAFT TRANSFERED-ARC-58 EQUIPMENT INSTALLED IN AIRCRAFT 55-3146, 8 NOVEMBER
(5) BROKEN ANTENNA MAST
(6) POOR CABLE SPLICE

Figure 3-1. KC-135 and B52 Aircraft Missions by Month and Performance of AN/ARC-58

3.1.2 Communication Fault Classifications

The communication fault classifications and codes used are as follows:

E - ARC-58 Equipment Failure - Communication difficulty was caused by an AN/ARC-58 equipment failure.

AE - Associated Equipment Failure - Communication difficulty was caused by an associated equipment failure (not an AN/ARC-58 equipment failure).

O - Operator Error - The operator was charged with an error when he was known to be at fault, and where apparent equipment malfunctions could not be verified by ground check and during the subsequent flight.

M - Maintenance Fault - Communication difficulty resulting from a malfunction experienced during the previous mission, which was not correctly diagnosed and therefore, not corrected, was considered to be a maintenance fault. Malfunctions caused by improper maintenance practices and procedures were also classified as maintenance faults.

X - Other or Unknown - The cause of communication difficulty could not be found or determined. If the operator was not believed to be at fault, the "other" classification was used: Propagation anomalies was the major suspect for this classification.

3.1.3 Summary of Results of Aircraft Missions and AN/ARC-58 Operations

The information contained in figure 3-1 is summarized in table 3-1. This table presents, by individual aircraft, the total missions flown, the number of satisfactory missions, the number of unsatisfactory missions categorized according to the communication fault, the total mission hours, and the aircraft mission success. The number of satisfactory missions includes those classified as satisfactory with write up; although some communication difficulty was experienced, satisfactory communication was possible. The AN/ARC-58 mission reliability, shown as adjusted mission success, was computed by classifying the unsatisfactory missions caused by operator error, associated equipment

TABLE 3-1. SUMMARY OF RESULTS OF AIRCRAFT MISSIONS AND AN/ARC-58 PERFORMANCE

	Aircraft Number	Total Missions	Satisfactory Missions (1)	UNSATISFACTORY MISSIONS CAUSED BY				Total Mission Hours	% Mission Success (2)	Adjusted % Mission Success (3)
				AN/ARC-58 Failure	Associated Equipment Failure	Operator Error	Other			
KC-135	58-0054	32	32	0	0	0	0	222	100.0	100.0
	57-2601	34	34	0	0	0	0	224	100.0	100.0
	56-3601	31	29	2	0	0	0	216	93.5	93.5
	56-3603	28	27	0	0	1	0	183	96.5	100.0
	Total (KC-135)	125	122	2	0	1	0	845	97.6	98.4
B-52	57-6503	21	19	1	0	0	1	167	90.5	95.3
	57-6505	17	17	0	0	0	0	141	100.0	100.0
	57-6507	16	14	0	0	2	0	144	87.5	100.0
	57-6509	19	16	1	2	0	0	158	84.2	94.7
	57-6510	17	11	2	1	2	1*	148	64.7	88.3
	57-6514	17	16	0	1	0	0	147	94.2	100.0
	Total (B-52)	107	93	4	4	4	2	905	86.9	96.3
Total (B-52 & KC-135)		232	215	6	4	5	2	1750	92.7	97.5

(1) Includes missions classified as satisfactory with write-up. Although some communication difficulty was experienced, satisfactory communication was possible. Therefore, these missions were considered to be satisfactory.

(2) % Mission Success = $\frac{\text{Satisfactory Missions}}{\text{Total Missions}}$ x 100

(3) Adjusted mission success computed by classifying unsatisfactory missions caused by associated equipment failures (not AN/ARC-58 failures) operator error, and "other" category of failures as satisfactory.

*Aircraft B-52 57-6510 flew one mission which was classified as being unsatisfactory because of a maintenance fault.

failure (not AN/ARC-58 equipment failure), and "other" category of failures as satisfactory.

The four (4) KC-135 aircraft and the six (6) B-52 aircraft flew 232 missions with a total flight time of 1750 hours with an over-all unadjusted mission success of 92.7%. The KC-135 aircraft flew 125 missions with a total flight time of 845 hours; 122 missions were satisfactory with an unadjusted mission success of 97.6%. The three unsuccessful KC-135 aircraft missions were caused by an operator error and two AN/ARC-58 equipment failures. The B-52 aircraft flew 107 missions with a total flight time of 905 hours; 93 missions were satisfactory with an unadjusted mission success of 86.9%. Of the 14 unsatisfactory B-52 aircraft missions, four were caused by operator error, four by associated equipment failures, one by maintenance fault, four by AN/ARC-58 equipment failures, and one by an unknown cause.

The adjusted mission success, computed to indicate the AN/ARC-58 mission reliability, was 98.4 and 96.3% for the KC-135 aircraft and the B-52 aircraft respectively.

3.2 AIRCRAFT MISSION COMMUNICATION FAILURES

In figure 3-1 a total of 16 missions are classified as being satisfactory with write-up and 17 missions are classified as being unsatisfactory. The 33 missions are detailed below according to aircraft number, date of mission, communication failure classification, and fault identification. Additional comments are included where appropriate. Further discussion of AN/ARC-58 failures or apparent failures is contained in paragraph 3.7.

3.2.1 KC-135 Aircraft

(a) No. 56-3601

16 July - Satisfactory/associated equipment failure. The interphone box was defective.

20 July - Unsatisfactory/ARC-58 equipment failure. Antenna Coupler CU-523 - #333 was reported to have malfunctioned.

25 August - Satisfactory/other. The radio operator reported the set operated properly during the first half of the mission. No stations

could be contacted after that. No malfunctions could be found during ground check following flight. The following flight on 28 August was satisfactory.

1 September - Unsatisfactory/ARC-58 equipment failure. The SG-179 reference generator in receiver R-761 #217 was defective.

(b) No. 56-3603

22 July - Unsatisfactory/operator error. The radio operator reported he did not have adequate instruction for the operation of the AN/ARC-58.

28 October - Satisfactory/operator error. The radio operator reported he could not contact any station. No malfunction could be found during ground check following flight.

3.2.2 B-52 Aircraft

(a) No. 57-6503

7 August - Unsatisfactory/other. After five successful contacts the AN/ARC-58 was inoperable. The transmitter was bench checked for four hours and the AN/ARC-58 was operated successfully in the aircraft during the flight-line maintenance check. Eleven subsequent flights were satisfactory.

29 September - Satisfactory/associated equipment failure. The interphone box was defective.

5 October - Satisfactory/operator error. The radio operator reported the set would not tune. The AN/ARC-58 was ground checked for one hour and no malfunction was found.

2 November - Unsatisfactory/ARC-58 equipment failure. Relay K1 in receiver R-761 #226 was inoperative because of a wiring short external to the relay.

(b) No. 57-6505

1 July - Satisfactory/ARC-58 equipment failure. The trouble was caused by a broken ground wire in the RE-284 relay assembly in Coupler Control C-1940 #79.

16 July - Satisfactory/other. The radio operator reported the set was extremely noisy on receive. The AN/ARC-58 operated properly during the ground check. Poor propagation conditions were assumed to be the cause of the trouble.

5 August - Satisfactory/operator error. The radio operator reported reception difficulty. The equipment was bench checked for five hours and ground checked in the aircraft. No malfunction was found.

31 August - Satisfactory/ARC-58 equipment failure. The radio operator reported a continuous tune tone on one channel. The AN/ARC-58 was operationally checked on the ground for 45 minutes and no malfunction could be found. The difficulty was believed to have been caused by an intermittent fault condition in the RE-284 relay assembly or operator error. The radio operated satisfactorily during the remainder of the evaluation program and no equipment repairs were made.

(c) No. 57-6507

29 June - Unsatisfactory/operator error. Only one radio contact was possible. The radio operator was believed to be at fault as the AN/ARC-58 system ground checked okay.

16 July - Satisfactory/operator error. The radio operator reported communication difficulty. The radio operator was believed to be at fault as the AN/ARC-58 system performed satisfactorily during ground check.

21 August - Unsatisfactory/operator error. The AN/ARC-58 was reported to tune continuously. The AN/ARC-58 performed satisfactory during ground check. Twelve successful flights were made following this flight.

(d) No. 57-6509

14 July - Satisfactory/operator error. The radio set functioned properly for five hours then went into fault. The AN/ARC-58 system was bench checked and no malfunction was found.

25 August - Satisfactory/ARC-58 equipment failure. The contact arm of switch S1F in transmitter T-605 #112 was broken. Satisfactory contacts were made throughout the mission.

16 September - Unsatisfactory/associated equipment failure. The antenna connection at the base of the antenna mast was broken.

28 September - Satisfactory/other. The radio operator reported heavy static which was apparently caused by poor propagation conditions. The AN/ARC-58 performed satisfactorily during ground check.

8 October - Unsatisfactory/associated equipment failure. The control wire splice between the control box and the receiver pulled loose causing intermittent operation.

19 November - Unsatisfactory/ARC-58 equipment failure. The lead pulled out of the tune core in coil Z-25 in the AM-1528 r-f tuner in receiver R-761 #258.

(e) No. 57-6510

15 July - Unsatisfactory/associated equipment failure. The long-wire antenna broke in flight.

14 August - Unsatisfactory/ARC-58 equipment failure. The SG-179 reference signal generator in receiver R-761 #314 was defective.

18 August - Unsatisfactory/ARC-58 equipment failure. The SG-179 reference signal generator in receiver R-761 #119 was defective.

24 August - Unsatisfactory/maintenance fault. The failure experienced during the mission of 18 August was not found until after this mission.

27 August - Satisfactory/other. The radio operator reported the AN/ARC-58 reception was weak and distorted. The trouble was caused by poor propagation conditions.

31 August - 3 September - Unsatisfactory/operator error. The radio operator was unable to contact anyone. The gain control on the control box was found in the off position. The AN/ARC-58 system ground checked okay after both missions.

11 September - Satisfactory/operator error. The radio operator complained of a whine in the receiver. The AN/ARC-58 ground checked okay.

14 October - Satisfactory/operator error. The radio operator reported the AN/ARC-58 wouldn't tune up on one channel. The system was operationally checked for over one hour and the write-up could not be duplicated.

(f) No. 57-6514

23 July - Unsatisfactory/associated equipment failure. The long-wire antenna broke in flight.

The unsatisfactory missions and satisfactory missions with write-up are tabulated according to aircraft and fault classifications in table 3-2. The data in table 3-2 shows that difficulty in establishing or maintaining communications occurred during 33(14.2%) of the 232 missions flown. The KC-135 and B-52 aircraft experienced this difficulty during 6 and 27 of the 232 missions respectively. Referring to table 3-1 the KC-135 aircraft flew 125 missions and the B-52 aircraft flew 107 missions.

TABLE 3-2. SUMMARY OF UNSATISFACTORY MISSIONS AND SATISFACTORY MISSIONS WITH WRITE UP

MISSION CLASSIFICATION		AN/ARC-58 FAILURE	ASSOCIATED FAILURE	OPERATOR ERROR	OTHER	TOTAL
KC-135	Satisfactory	0	1	1	1	3
	Unsatisfactory	2	0	1	0	3
TOTAL		2	1	2	1	6
B-52	Satisfactory	3	1	6	3	13
	Unsatisfactory	4	4	4	2*	14
TOTAL		7	5	10	5	27
GRAND TOTAL		9	6	12	6	33

* - Aircraft flew one mission classified as unsatisfactory because of a maintenance fault.

The AN/ARC-58 was directly responsible for difficulty during 9(4%) of the 232 missions. Associated equipment, operator error, and "other" failures were responsible for communication difficulty during 6(2.6%), 12(5.2%) and 6(2.6%) of the 232 flights respectively. Of the 125 KC-135 missions 2(1.6%) were unsatisfactory because of AN/ARC-58 failure; of the 107 B-52 missions, 4(3.7%) were unsatisfactory because of AN/ARC-58 failure.

3.3 PRODUCTION AN/ARC-58 RELIABILITY

The purpose of this study was to determine the reliability of production AN/ARC-58 and to compare this value with the reliability of preproduction systems. This section summarizes the data obtained under this study and provides a comparison of the reliability of the production and preproduction AN/ARC-58. Reliability will be expressed in terms of mean-time-between-failure of the equipment during aircraft missions.

For purposes of MTBF calculation, a failure is defined as an equipment failure or malfunction that was directly responsible for communication difficulty which caused an unsatisfactory mission. The time used in the MTBF calculations is the actual aircraft flight time in hours.

The data in table 3-3 shows flight hours, the number of unsatisfactory missions classified according to reasons for communications failure, the mission MTBF, and the AN/ARC-58 mission MTBF. The mission MTBF's were calculated by dividing the total aircraft hours by the appropriate number of failures. The effect of operator error and maintenance faults on mission MTBF is shown by a comparison of the mission MTBF and the adjusted mission MTBF. The AN/ARC-58 mission MTBF was calculated by considering only those unsatisfactory missions caused by AN/ARC-58 equipment failures.

The production AN/ARC-58 demonstrated a mission MTBF of 423 and 226 hours in the KC-135 and B-52 aircraft respectively. The over-all production AN/ARC-58 mission MTBF was 292 hours, computed by dividing the total aircraft hours (1750) by six (6) unsatisfactory missions caused by AN/ARC-58 failures.

TABLE 3-3. AIRCRAFT COMMUNICATION MISSION AND AN/ARC-58 MISSION MTBF

		UNSATISFACTORY MISSIONS CAUSED BY				MEAN-TIME-BETWEEN-FAILURE HOURS (1)		
Aircraft	Hours	AN/ARC-58 Failure	Associated Failure	Operator Error	Other	Mission	Adjusted Mission (2)	ARC-58 Mission (3)
KC-135	845	2	0	1	0	282	423	423
B-52	905	4	4	4	2	64.7	113	226
Overall	1750	6	4	5	2	103	175	292

(1) $\text{MTBF} = \frac{\text{Hours}}{\text{Failures}}$

(2) Adjusted Mission MTBF was computed by classifying unsatisfactory missions caused by operator errors and "other" faults as satisfactory.

(3) Actual AN/ARC-58 mission MTBF was computed by classifying unsatisfactory missions caused by operator errors, "other", and associated equipment (not AN/ARC-58) failures as satisfactory.

It will be noted that both the number of mission hours and unsatisfactory missions caused by AN/ARC-58 failures are relatively small. Therefore, the true MTBF of the AN/ARC-58, at a high confidence level lies within broad limits. This may be determined mathematically, for a 90% confidence level, as follows:

$$\overline{MTBF} = MTBF \pm 1.64\sigma, \text{ and } \sigma = \frac{MTBF}{\sqrt{f}}$$

$\overline{MTBF}$ = True Value

MTBF = Calculated Value

σ = Standard Deviation

f = Number of Failures

From the figures obtained,

$$\overline{MTBF} = 292 \pm 1.64\frac{292}{(\sqrt{6})} = 292 \pm 195$$

Therefore, based on the amount of data obtained, and at a 90% confidence level, the true AN/ARC-58 mission mean-time-between-failure lies between 97 and 487 hours.

It will also be noted that a considerable difference in mission MTBF was obtained for the AN/ARC-58 as used in the B-52 and the KC-135. This difference is attributed to: (1) the more severe equipment operating environment in the B-52 installation and (2) measurement accuracy involved with small numbers of failures and operating hours, as described in the preceding paragraph.

3.4 COMPARISON OF THE PRODUCTION AND PREPRODUCTION AN/ARC-58 RELIABILITY

A comparison of the production and preproduction AN/ARC-58 reliability is shown in table 3-4. The data shown were taken from table 3-3 above, and table 2-4 in WADC-TR-59-501.

The production AN/ARC-58 demonstrated an over-all mission MTBF of 292 hours as compared to the preproduction AN/ARC-58 mission MTBF of 85 hours. This represents a 3.4 to 1 improvement in reliability for the production AN/ARC-58. The aircraft mission MTBF and adjusted mission MTBF also reflect about a 3 to 1 improvement in performance of the production AN/ARC-58 as compared to the performance of the preproduction

AN/ARC-58. It will be noted in table 3-4 that an inherent AN/ARC-58 MTBF was calculated for the preproduction system by discounting AN/ARC-58 design failures in addition to "other," maintenance fault, and operator error. The inherent AN/ARC-58 MTBF for the production radio is considered equivalent to AN/ARC-58 mission MTBF, since no chronic deficiency was apparent during the test (only one design deficiency was reported).

A comparison of the number of failures and failures/mission (%) of the production and preproduction AN/ARC-58 installations relative to the total missions flown during each study is shown in table 3-5. The data shown were taken from table 3-2 above, and table 2-3 and figure 2-1 in WADC-TR-59-501.

The data in table 3-5 show a marked decrease in the number of AN/ARC-58 failures per mission and maintenance faults per mission. Associated equipment failures and operator errors per mission remained about the same.

Fifty-two equipment failures occurred during the E&ST evaluation on the preproduction equipment which were considered to be the result of AN/ARC-58 design deficiencies; 20 associated equipment failures occurred. Only one AN/ARC-58 design failure (switch SIF in transmitter T-605) was reported on the ten systems during the production AN/ARC-58

TABLE 3-4. COMPARISON OF THE PRODUCTION AND PREPRODUCTION AN/ARC-58 RELIABILITY

		MEAN-TIME-BETWEEN FAILURE, HOURS			
	Aircraft	Mission	Adjusted Mission	ARC-58 Mission	Inherent ARC-58 Mission
Preproduction AN/ARC-58	KC-135	48.0	79.5	100	153
	B-52	28.5	41.0	68.1	153
	Composite	37.7	57.5	84.8	153
Production AN/ARC-58	KC-135	283	423	423	
	B-52	64.7	113	226	
	Composite	103	175	292	

TABLE 3-5. COMPARISON OF THE PRODUCTION AND PREPRODUCTION AN/ARC-58 IN-FLIGHT FAILURES AND PERCENT FAILURE/MISSION

	PREPRODUCTION AN/ARC-58 STUDY		PRODUCTION AN/ARC-58 STUDY	
	In-Flight Failures (1)	Failures/Mission (%)	In-Flight Failures (2)	Failures/Mission (%)
AN/ARC-58 Failure	63	15.4	9	3.9
Associated Equipment Failure	17	4.2	6	2.6
Operator Error	9	2.2	12	5.2
Maintenance Fault	19	4.6	1	0.4

$$\% \text{ Failures/Mission} = \frac{\text{Failures}}{\text{Missions}} \times 100$$

(1) Aircraft participating in preproduction AN/ARC-58 study flew 409 missions

(2) Aircraft participating in production AN/ARC-58 study flew 232 missions

evaluation. Corrective action to improve the reliability of switch SIF had been initiated prior to the completion of the E&ST program; however, the transmitter that failed was an early production unit not yet incorporating the redesigned switch. Six failures were reported during this study program; none was similar to those occurring during the E&ST study program.

3.5 AN/ARC-58 COMPONENT OPERATION

The aircraft operating time, by serial number, for each of the AN/ARC-58 components used in the ten aircraft employed in this study is tabulated in table 3-6.

Replacement components are noted with an asterisk. Regarding component replacement, the practice was to install and operate the replacement component in the aircraft only until the original component was repaired. The repaired component was then reinstalled in the aircraft. The C-1939 control box is not tabulated in table 3-4 since no control box failures were reported. It is to be noted that it was necessary to replace only

TABLE 3-6. AN/ARC-58 COMPONENT OPERATING TIME BY SERIAL NUMBER

AN/ARC-58 COMPONENTS							
R-761		T-605		CU-523		C-1940	
SERIAL NO.	HOURS	SERIAL NO.	HOURS	SERIAL NO.	HOURS	SERIAL NO.	HOURS
119*	20	97	147	62	144	66	148
211	144	101	167	82	141	67	147
217*	42	103	148	88	167	73	167
226	167	112	100	94	224	79	132
238	222	119	144	133	158	81	144
240	141	131	141	144	147	82	158
256	147	316	183	165	148	102	224
258	158	368	216	244	222	292	222
314	102	373	224	284	183	303*	204
401	183	383	222	290	150	391	183
409	174	415*	58	333*	66	400	12
431	224					? *	9
503*	26						
TOTAL OPERATING TIME - 1750 HOURS							

* - Replacement component.

one T-605 transmitter during 232 KC-135 and B-52 aircraft missions; the CU-523 Antenna Coupler was also replaced only once, the C-1940 Antenna Coupler Control was replaced twice, and the R-761 Receiver was replaced three times.

3.6 AN/ARC-58 COMPONENT MTBF

The AN/ARC-58 component operating hours, total component failures experienced during this program, and calculated component MTBF is tabulated in table 3-7. The component MTBF was computed by dividing the operating hours by the number of failures.

The failures recorded in this table represent AN/ARC-58 failures that occurred during both the unsatisfactory missions and the satisfactory missions with write-up. Although the AN/ARC-58 components were operated during bench checks and flight-line maintenance, complete records of this time were not kept; therefore, the time used in the MTBF calculations is the actual recorded aircraft missions time in hours.

As pointed out previously in paragraph 3.3, the limited data available will permit only a crude measure of component MTBF with a high degree of confidence.

TABLE 3-7. AN/ARC-58 COMPONENT HOURS, FAILURES, AND CALCULATED MTBF

AN/ARC-58 COMPONENT FAILURES AND MTBF					
Component:	R-761	T-605	CU-523	C-1940	C-1939
Hours	1750	1750	1750	1750	2595*
Failures	5	1	1	2	0
MTBF	350	1750	1750	875	Infinite

*The KC-135 installation contains two C-1939 control boxes.

3.7 EQUIPMENT FAILURES

This paragraph lists and describes in detail the AN/ARC-58 and associated equipment failures reported during the evaluation. Also included are details of AN/ARC-58 failure analysis, and a discussion of appropriate corrective action including parts replacement and equipment redesign effected to improve equipment reliability.

3.7.1 AN/ARC-58 Equipment Failures

A total of nine AN/ARC-58 equipment failures were reported during the evaluation program. Six of these failures were responsible for causing communication difficulty resulting in unsatisfactory missions. The AN/ARC-58 equipment failures are discussed below according to component, module, aircraft number, and mission date.

3.7.1.1 R-761/ARC-58 Receiver

(a) SG-179 Reference Signal Generator

(1) A/C 57-6510, 14 August 1959: Transistor Q6, Type 2N128, was defective resulting in no 2.4 mc output and garbled reception in receiver R-761 #314. The defective transistor was replaced, restoring the module to proper operation.

(2) A/C 56-3601, 1 September 1959: The 2.4 mc output of the SG-179 was 35 cycles high in frequency resulting in garbled reception in Receiver R-761 #217. The fault was corrected by adjusting L1.

(3) A/C 57-6510, 24 August 1959: The SG-179 was rejected as being defective. The failure occurred in Receiver R-761 #119 which was a replacement for Receiver R-761 #314. A failure diagnosis was not attempted at the site and no report of failure diagnosis has been received.

The type 2N128 transistor failure is believed to be a random part failure. Factory test records indicate the rejection rate of the type 2N128 transistor in the SG-179 module is about 1.5% which is not excessive. The R&D design group has investigated the use of the type 2N710 transistor in this module with satisfactory results. It is anticipated the type 2N710 transistor will be used in the SG-179 module as a part of the proposed AN/ARC-58 Product Improvement Program currently under study by the Air Force.

The measured 35-cycle frequency error of the 2.4 MC output of the SG-179 is excessive. The reason for a sudden change in reference frequency could not be determined. The reception difficulty was not apparent during ten previous flights.

(b) AM-1528 R-F Tuner

(1) A/C 57-6509, 19 November 1959: The core lead in tune coil Z-25, R-761 #258, pulled out of the ferrite core.

Similar failures have occurred on this part during the equipment factory reliability test. The part manufacturer was requested to improve the core lead seal. In addition the parts specification was revised in June 1959 to require a 5-lb axial pull test between the junction of the core and the core lead and between the threaded screw and the core insert. Receiving Inspection conducts the axial-pull test on the tune cores prior to distribution to the production assembly line. No reliability test failures have been reported on the part since June 1959. No other field failures of this type have been reported on this part.

(c) Chassis

(1) A/C 57-6503, 2 November 1959: Receiver R-761 #226 was reported as inoperative because of an intermittent wiring short to the pins of on-off relay K-1. The trouble was corrected by redressing the leads to the relay. The cause for the trouble is unknown.

3.7.1.2 T-605/ARC-58 Transmitter

(a) A/C 57-6509, 27 August 1959: The contact arm on switch SIF in T-605 #112 was broken. All contacts attempted during this mission were successful; therefore, the mission was classified as satisfactory with write-up. The first transmission was reported to be weak. The failure did not affect the operation of the radio set.

The switch SIF contact arm was a major design problem. Results of extensive life tests proved the switch was not adequate for this application. The common failure with this switch was the breaking of the contact arm at the top right-angle bend. An adequate solution to the problem was achieved by redesigning the contact arm. The new switch has a "U-shaped" configuration eliminating all sharp bends and angles. No failures have been reported on the redesigned switch SIF since incorporation in production T-605 transmitters approximately 1 May 1959. The T-605 #112 was not equipped with the redesigned switch since it was an early production unit.

3.7.1.3 CU-523/ARC-58 Antenna Coupler

(a) A/C 56-3601, 20 July 1959: The AN/ARC-58 was reported as being inoperative. Only two transmissions were attempted with negative results. Transmitter T-605 #373 operated properly during bench check and was returned to the aircraft. Antenna Coupler CU-523 #290 and Antenna Coupler Control #400 were replaced by CU-523 #333 and C-1940 #303 in the aircraft.

The coupler and coupler control both operated properly during bench checks and could not be made to malfunction. There was evidence of arcing indicated by burnt spots on the inductor drum, tape and tap assembly in the antenna coupler. The Field Engineer reported evidence of oil on the tap and inductor drum assembly which was apparently responsible for the arcing. The air filter in the rear of the case was checked and found to contain excess oil.

The air filter is a purchased part impregnated with a high-grade oil possessing the viscosity characteristics of SAE 30 or better and is capable of withstanding the specified operating environments of the AN/ARC-58 without thinning. The air flow through the Antenna Coupler is sufficient to draw excess oil into the coupler assembly. Specific maintenance instructions are labeled on the air filter, one of which states, "the filter must be drained for a period of 24 hours after filling with oil before installation in the case." Though the AN/ARC-58 has been charged with this failure, there is possibility that the failure occurred because of maintenance fault. Antenna Coupler #290 was cleaned and reinstalled in the aircraft 25 August 1959 and operated properly with no failures throughout the remainder of the evaluation program.

3.7.1.4 C-1940/ARC-58 Antenna Coupler Control

(a) RE-284 Relay Assembly

(1) A/C 57-6505, 1 July 1959 - First mission of this aircraft during this evaluation: The transmitter was reported to hunt continuously after four hours of

flight. Nine successful contacts were achieved before the failure became apparent and the mission was classified satisfactory with write-up.

The RE-284 relay assembly in coupler control C-1940 #79 was found to be inoperative. The ground wire to the primary of transformer T-1 was reported to be broken or burned in two. The ground connection was repaired restoring the unit to proper operation. The trouble was apparently caused by a poor solder connection.

(2) A/C 57-6505, 31 August 1959 - The radio operator reported a continuous tune tone on frequency 9.026 MC. The AN/ARC-58 was operationally checked for 45 minutes on the ground and no malfunction could be found. The difficulty was believed to have been caused by an intermittent fault condition in the relay assembly of C-1940 #79 or an operator error. The radio set operated satisfactorily during the remainder of the evaluation program and no equipment repairs were made.

3.7.2 Associated Equipment Failures

This paragraph lists and describes briefly the six associated equipment failures that were reported during this evaluation.

(a) Long-Wire Antenna

(1) A/C 57-6510, 15 July 1959: The long-wire antenna broke during flight six hours after take off.

(2) A/C 57-6514, 23 July 1959: The long-wire antenna broke during flight four hours after take off.

The difficulties experienced with the long-wire antenna installation indicate aircraft and/or antenna design problems, and though not directly part of the AN/ARC-58 equipment, could greatly reduce the performance of the AN/ARC-58 communication system if not corrected.

(b) Interphone Boxes

(1) A/C 56-3601, 16 July 1959: Flight line maintenance found a broken wire in the interphone box. This failure disrupted all interphone operation in the aircraft.

(2) A/C 57-6503, 29 September 1959: The AN/ARC-58 was reported to leak into the interphone circuit. The C-824 interphone box was repaired.

(c) Aircraft Wiring

(1) A/C 57-6509, 16 September 1959: The AN/ARC-58 operated properly for the first three hours of the mission after which no operation was possible. The antenna connection at the base of the antenna mast was broken.

(2) A/C 57-6509, 8 October 1959: The operation of the radio set was reported to be intermittent. The control-wire splice connections between the C-1939 control box and the R-761 receiver pulled loose. This is airframe manufacturer's installation.

SECTION IV

CONCLUSIONS

The AN/ARC-58 production equipment accumulated 1750 hours during 232 KC-135 and B-52 aircraft missions. AN/ARC-58 Mission MTBF was 292 hours; in KC-135 and B-52 aircraft the mission MTBF was 423 and 226 hours respectively.

The predicted reliability of the AN/ARC-58 in terms of MTBF and based on component part failure rates and component part complement was 167 hours. The design goal was 200 hours. The results of the evaluation on production equipment indicates the reliability of the system exceeds considerably both the predicted and design goal reliability.

A comparison of the results obtained from the two evaluation programs shows the MTBF of production to be more than three times that of the reliability of the preproduction system. Fewer failures per mission flown were reported, and only one AN/ARC-58 design failure occurred during the production study as compared to 52 design failures occurring during the preproduction study. The 1750 hours of operation accumulated on ten production systems with the occurrence of only one design failure indicates that the design problems previously experienced on the preproduction systems have been definitely corrected.

The two formal field evaluations conducted on the AN/ARC-58 have clearly demonstrated the need for such programs. Design deficiencies not readily evident or disclosed through comprehensive reliability programs during design and development, or detected during factory tests, will be identified during reliability field surveillance programs on preproduction units; a follow-up surveillance program on production equipment will determine the degree of success obtained in eliminating reliability degrading factors.

DATA COLLECTION PROCEDURES FOR OPERATIONAL EVALUATION OF RADIO SET AN/ARC-58

PROJECT ONE-SIDE

COLLINS RADIO COMPANY
Cedar Rapids, Iowa

WADD TR 60-142

APPENDIX I

APPENDIX I

DATA COLLECTION PROCEDURES FOR OPERATIONAL EVALUATION OF RADIO SET AN/ARC-58

INTRODUCTION

Project One-Side is the evaluation of the performance of production AN/ARC-58 radio sets as specified in item 55 of Contract AF 30(635)-4504.

The booklet was prepared to acquaint cognizant personnel and the assigned Collins Field Service Engineers with the procedures of this evaluation program.

The information contained herein outlines the data collecting procedures, the data reporting forms, and mailing instruction.

DATA COLLECTION PROCEDURES

Primary sources of data for the AN/ARC-58 Operational Evaluation Program will be:

(1) Aircraft Radio Log

(2) Weekly Status Report

(3) Failure-Malfunction Report

AIRCRAFT RADIO LOG

Arrangements are to be made by WADD for the third copy of the aircraft radio log to be delivered to Collins after each flight. These logs will report the frequencies used, station contacts, number of contacts attempted, number of contacts completed, mode or type of emission used, and other information pertinent to an analysis of the operational use of the equipment. The A/C radio logs are classified information to be routed through the appropriate Air Force agency.

WEEKLY STATUS REPORT

The Weekly Status Report, to be filled out by the Collins Field Engineer, will provide a summary of AN/ARC-58 performance during all flights and ground-bench tests. This

report is to be kept current on a day-to-day basis with an entry made for each flight, and ground-bench operational malfunction. Each week's report will be mailed to Cedar Rapids not later than Friday of the reporting week. The data required in this report follows:

Column 1. Aircraft number.

Column 2. Date of flight.

Column 3. Total hours of flight.

Column 4. AN/ARC-58 operating hours if different from flight hours.

Column 5. A Failure-Malfunction Report will be initiated for any flight where an equipment write-up results in an equipment removal and the report number entered here. The number of the FMR will be entered in Column 5.

Column 6. The equipment write-up will be a word-for-word transcript of the operator's debriefing comments or in case of a ground failure, comments of the operator/technician.

Column 7. The Field Engineer's comments will be entered under "Remarks".

FAILURE-MALFUNCTION REPORT

The Failure-Malfunction Report will be completed by the Collins Field Engineer for each equipment for which a malfunction has been reported, either during flight or ground test. These reporting forms will be prenumbered. A Failure-Malfunction Report will be initiated when the Weekly Status Report entries are made. It is unlikely that the Failure-Malfunction Report can be completed in full at this time. However, lines 1, 2, 3, 12, and 13A can be completed immediately and the form placed in a pending file for follow-up action. As soon as the particular equipment has been repaired and the required information entered, the Failure-Malfunction Reports will be mailed to Cedar Rapids. In cases where shop tests fail to duplicate the reported trouble, this fact will be entered on the report.

The Weekly Status Report and the Failure-Malfunction Report are to be filled out in triplicate. The originals will be mailed to Cedar Rapids. The Field Service Engineer will retain the remaining two copies. One copy is intended for Air Force use if requested.

At the start of this program all aircraft participating in the evaluation and all original AN/ARC-58 Installations in these aircraft and spare AN/ARC-58 Installations, if any, are to be recorded and this information forwarded to Cedar Rapids.

MAILING INSTRUCTIONS

The Weekly Status Report and the Failure-Malfunction Reports are to be mailed to the attention of:

RELIABILITY ENGINEERING GROUP DEPARTMENT DA5

Business reply envelopes will be provided.

RADIO LOG

RADIO CALLS	DATE	EQUIP ON	Page of pages	
TACTICAL	PREFLITE	OVER FIELD	SQUADRON	FLIGHT NO.
VOICE	TAXI	LAND	A/C NUMBER OR LOCATION	
COLLECTIVE	AIRBORNE	EQUIP OFF	PILOT OR OIC	
SPECIAL	MISSION OR NET		OPERATOR	

TIME	TO/FROM—	FREQ.	MESSAGE/REMARKS

LOCATION _____

AIRCRAFT TYPE _____

AF-30 (635)-4504
PROJECT ONE SIDE
OPERATIONAL EVALUATION PROGRAM

WEEKLY STATUS REPORT
AN/ARC-58

COLLINS RADIO COMPANY
CEDAR RAPIDS, IOWA

ACFT. NO.	DATE	FLIGHT HOURS	ARC-58 HOURS	FMR NO.	EQUIPMENT WRITE-UP	REMARKS

AF-30(635)-4504
PROJECT ONE SIDE
OPERATIONAL EVALUATION PROGRAM

FAILURE-MALFUNCTION REPORT NO. 1234
AN/ARC-58

COLLINS RADIO COMPANY
CEDAR RAPIDS, IOWA

1. REPORTING ORGANIZATION	LOCATION
2. REPORTED BY	DATE OF FAILURE/MALFUNCTION
3. A/C TYPE	A/C SERIAL NO.

4. MAJOR UNIT & SERIAL NO.	MODULE TYPE	MODULE SERIAL NO.	PART SYMBOL

5. COLLINS PART NUMBER	PART NAME OR TUBE TYPE	MANUFACTURER

6. FAILURE OCCURRED DURING:
☐ BENCH TEST ☐ PRE FLT. CHECK ☐ FLT. OPRNS. ☐ MNTNCE TEST ☐ OTHER (Specify) _____

7. TIME IN SERVICE: TOTAL HOURS	Elapsed Operating Time From Start of Mission to Failure	REPAIR TIME (Hours in tenths)

8. FIRST INDICATION OF TROUBLE

9. DESCRIPTION OF FAILURE

10. FAILED DURING OR DUE TO

11. MISCELLANEOUS COMMENTS

12. USER COMMENTS (Not edited or interpreted)

13. (A) WAS FLIGHT OPERATION DELAYED DUE TO MALFUNCTION OF EQUIPMENT? ☐ Yes ☐ No
(B) IF UNIT WAS REPAIRED PROMPTLY AND RETURNED TO SERVICE IN ORIGINAL AIRCRAFT, HOW MUCH AIRCRAFT OPERATING TIME WAS LOST? (Total hours) _____

14. (A) DISPOSITION OF EQUIPMENT:	(B) DISPOSITION OF MODULE:	(C) REPAIRED BY:
☐ RETURNED TO SERVICE ☐ RETURNED TO OPERATIONS AREA AS SPARE ☐ UNIT SENT TO COLLINS FOR REPAIR	☐ RETURNED TO SERVICE ☐ RETURNED TO OPERATIONS AREA AS SPARE ☐ UNIT SENT TO COLLINS FOR REPAIR	☐ AIR FORCE ☐ COLLINS: NAME _____

DO NOT WRITE IN THIS SPACE

APPENDIX II

APPENDIX II

COLLINS AN/ARC-58 RELIABILITY PROGRAM

The design and development contract for the AN/ARC-58 was let to Collins Radio Company in July of 1955, and at that time the contract did not contain any requirements or provisions for a specific reliability program. However, in July of 1956, by contract amendment, a requirement was added by the Air Force that Collins submit for approval a proposed formal reliability program. Approval of the submitted program was received early in 1957. The phases of the reliability program proposed for the AN/ARC-58 and subsequently followed are listed below.

1. Part and Material Application
2. Part and Material Qualification Testing
3. Vendor Approval
4. Part and Material Failure Analysis and Corrective Action
5. Module and Equipment Thermal Analysis
6. Module and Equipment Environmental Tests
7. Part and Material Reliability Analysis
8. Mathematical Analysis and Reliability Prediction
9. Factory System Reliability Tests

A considerable portion of the program actually started prior to approval, or immediately after the original contract was signed. The reason for this is that items 1 through 6 are normal procedures and practices of Collins during the design and development stage of any equipment, commercial and military.

Regarding the program outlined for the AN/ARC-58, or for any similar program, it is pointed out that all the items on the chart, with the exception of items 5, 6, and 9, are the responsibility of the Reliability Department which structurally is on a plane equal to that of

the design and development departments. There are a total of 117 personnel in the Reliability Department of which 41 are engineers, all specialists in the field of reliability. Items 5 and 6 are responsibilities of the project engineers, item 9 is a manufacturing responsibility. A brief discussion of each item will suffice to outline the program performed and show the specific reliability effort involved.

Part and material application engineering is performed by specialists who serve primarily as consultants to design and development engineers. Each of the 17 application engineers is responsible for a category of parts or materials. He is thoroughly familiar with the mechanical, electrical, and environmental stress capabilities of parts and materials, theory of operation and design, and processes and materials used. As a consultant to the design and development engineers he recommends specific parts and materials for specific application. The application engineer also analyzes test data and failed parts, and works with Quality Control, Product Analysis, and Final Test departments of the Manufacturing Division, maintains necessary contact with part and material vendors, and is responsible for the preparation of part and material specifications and standards. This activity starts during the earliest stages of design and development.

Qualification testing of parts and materials, Item 2, also started early during the AN/ARC-58 program. Each nonstandard part was thoroughly tested in the Component Part Test Laboratory to determine compliance with rigid specifications. The tests included complete electrical, mechanical, thermal, and environmental tests. Several vendors were always considered for each part; when parts from one vendor failed to meet requirements, steps were taken to use the parts from an alternate source. When all efforts to find suitable sources failed redesign of circuits to eliminate such parts was mandatory.

As an adjunct to qualifications testing a strict policy of the company permits the purchase of parts only from those vendors who have been formally approved through the qualification testing program. Under this procedure, item 3, there is assurance that parts and materials purchased for the AN/ARC-58 are fully qualified and approved.

Item 4, part and material failure analysis and corrective action, has been a continuous process since inception of design of the AN/ARC-58, and will continue through the field usage period. The data collected under field usage includes that obtained under items 53 and 55 of contract AF30(635)4504 and information obtained by Collins Field Engineers from other AN/ARC-58 installations. Failures have been thoroughly analyzed whether they occur during part qualification testing, equipment bench testing, environmental testing, or field usage. The corrective action is determined by the nature of the failure, and may involve circuit redesign, replacement of component parts, 100% testing of incoming shipments, mechanical redesign, etc.

Module and equipment thermal analysis, item 5, has been extensively pursued in the AN/ARC-58 program. A detailed analysis of each module was performed which involved literally thousands of thermocouple measurements at various cooling air flow rates to determine part surface temperature. As an example of the results of this phase of design and reliability effort, maximum bulb temperature of various tubes, with the exception of the power and driver tubes, is 100°C at +55°C.

Item 6, modules and equipment, as applicable, were subjected to all environmental tests, including humidity, vibration, shock, and temperature altitude. Electrical tests were performed on modules before and immediately after humidity tests; each module was subjected to the vibration test; and equipments were subjected to all tests.

The next item, part and material reliability analysis, involved an extremely detailed analysis of each part and material relative to its individual application. This analysis was performed by reliability engineers, who are members of the Reliability Engineering Group, and who are independent of design and development engineers. A design criterion was the adequate derating of parts, as required by individual application. A nominal derating factor of "two" was applied to such parts as resistors, capacitors, tubes, transistors, and diodes. In some cases it was as great as four or five. Application of each part, with respect to derating, was a basic responsibility of the reliability engineer in his analysis. Relays were thoroughly investigated for contact loads, particularly dry-circuit applications. The

redundancy of printed wiring and printed wiring connectors was checked; mechanical mounting of parts was analyzed relative to strength, ease of assembly and maintenance; the use of standard and preferred parts was reviewed; and each part specification was reviewed to assure that all specifications were compatible with circuit and equipment specification requirements. Special tests were instigated by the reliability engineer on parts, materials, and circuits where marginal conditions, from a reliability standpoint, were observed. For example, sixty 6CL6 driver tubes were subjected to an 8000-hour life test, 30 at an envelope temperature of 150°C and 30 at an envelope temperature of 200°C. This was necessary to establish cooling requirements for the tube to give reliable and acceptable life. As another example, 10,000-hour life tests were conducted on 180 tantalum capacitor samples under specific conditions. The foregoing illustrated some of the details observed and the responsibilities of the reliability engineer in the part and material reliability analysis program.

On conclusion of the reliability analysis of each module and/or equipment, a formal report was prepared by the reliability engineer and submitted to the project engineer. The report detailed all findings and listed all necessary corrective recommendations.

Part and material analysis by independent reliability engineers is considered by reliability authorities to be a most effective procedure to eliminate design weaknesses. This was verified in the AN/ARC-58 program. Over 600 recommendations for changes were made as a result of this analysis. These recommendations for changes, of course, ranged from those that were relatively insignificant from the standpoint of reliability to those that were considered crucial. Compliance with change recommendations by the project engineer was essentially 100%.

The 8th item, mathematical analysis and prediction of inherent reliability, was performed concurrently with item 7. This was based on the part population of the equipment and failure rates determined through a study performed ten months previously.

The 9th item is a manufacturing reliability effort and consists of an 80-hour bench test, conducted to simulate field operating conditions. As a part of this program, detailed records are kept of all malfunctions or failures with an analysis performed by the reliability engineering group in conjunction with the part and material application engineers and the project engineers.

APPENDIX III

APPENDIX III

LIST OF TEST EQUIPMENT AT CASTLE AIR FORCE BASE

AN/ARM-41	Module Tester
GRM-10	Bench Test Harness
TS-1063	System Tester
TS-1064	System Tester
PSM-6	Voltmeter
ME-26A/V	VTVM
URM-25	Signal Generator
R-390/URR	Receiver
ME-74	VTVM
DuMont 304	Oscillograph
USM-26	Frequency Counter
Model CDA5	Decade Capacitor
C-825A/AIC-10	Interphone
LS-18A/AIC-10	Speaker
H-78	Headset and Microphone

APPENDIX IV

APPENDIX IV

LIST OF TEST EQUIPMENT AT TRAVIS AIR FORCE BASE

AN/ARM-41	Module Tester
GRM-10	Bench Test Harness
PSM-6	Voltmeter
R-390/URR	Receiver
USM-26	Frequency Counter
USM-50	Oscilloscope
TS-382	Audio Oscillator
SG-85/URM-250	RF Signal Generator
TS-585	Output Meter
HP-410B	VTVM
TV-7	Tube Checker
C-824/AIC-10	Interphone

UNCLASSIFIED